Bulletin No. 63 February 15, 1923.

COMMONWEALTH OF PENNSYLVANIA

DEPARTMENT OF INTERNAL AFFAIRS
James F. Woodward, Secretary

BUREAU OF TOPOGRAPHIC AND GEOLOGICAL SURVEY
George H. Ashley, State Geologist

BROWN IRON ORES IN PENNSYLVANIA

By

J. Ross Corbin

Production. From almost 500,000 tons in 1889, the annual output of brown ores in Pennsylvania has fallen to 10,000 tons or less. In recent years much of this amount has been the variety known as bog ores, used for gas purification purposes; but some small discontinuous operations have been conducted at a few other deposits. Also, some brown ore has been obtained as a by-product in quarrying operations and in digging sand and gravel.

Reasons for decrease. The reasons given by former producers for the decrease in production have been the invasion of the markets by the Lake Superior ores, inability of the local ores to stand the freight charges, increasing labor costs, and similar causes. These are of an external nature. In relatively few cases is the deposit reported exhausted; hence it is a natural conclusion that under favorable conditions brown-ore mining in Pennsylvania may again become a large industry.

Future Development. Advances in the art and machinery of mining have been great during the last two decades. Various experiments have been made tending to improve or beneficiate the brown ores, thus giving a higher grade product for shipment. It has been demonstrated that the ores can be made magnetic by heating in a reducing atmosphere. Subsequent magnetic treatment will raise the iron content from about 35 to 55 per cent. In attempts to remove or lower the phosphorus content, the U. S. Bureau of Mines* conducted leaching experiments.

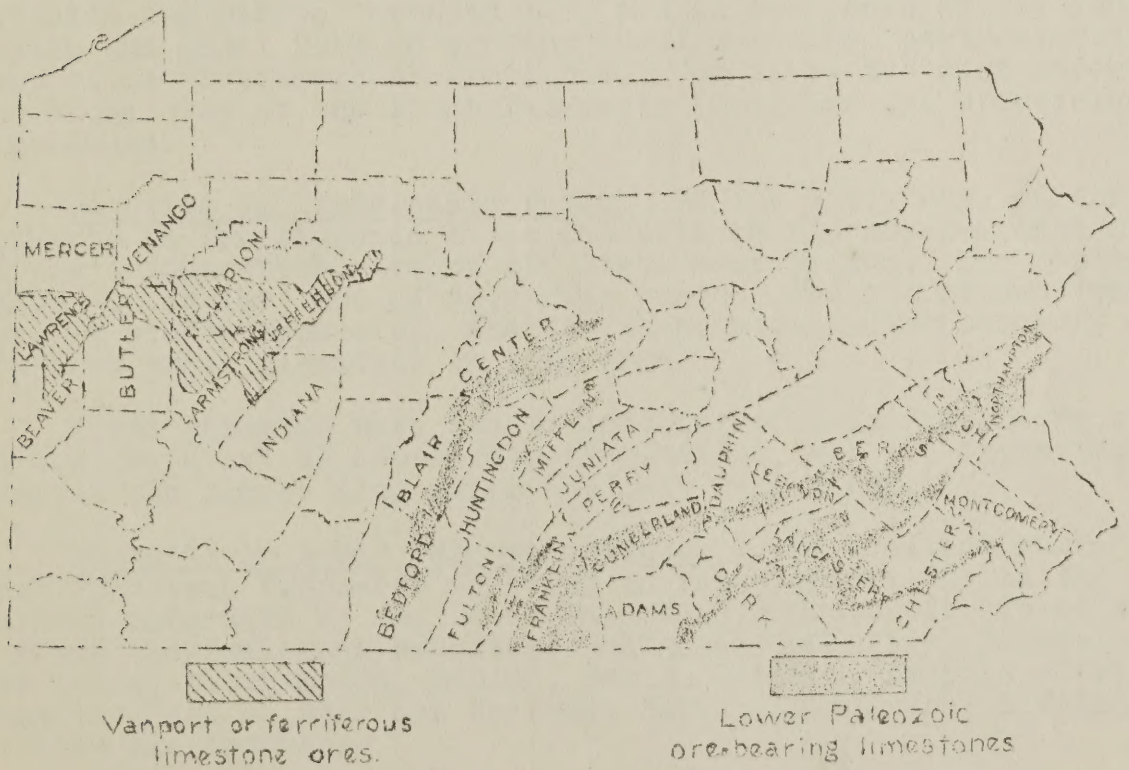
* Winslow, R. M., "Leaching Iron Ores for Phosphorus," U. S. Bureau of Mines Reports of Investigations, Serial No. 2266, July, 1921.

Although not successful, these tests were of great value. Experiments have been conducted in the metal industry, using material containing much more phosphorus than allowed by standard specifications.* Although the results were remarkably successful and startling, the iron and steel trade is not yet prepared to alter its standards.

The Lake Superior ores are by no means exhausted, but the tonnage which reaches the open market will gradually decrease and the comparative price will rise. It seems probable, therefore, that in the not far distant future the brown-ore industry in Pennsylvania may regain some of its former greatness, although uses of the ores will be limited to certain definite fields in the iron and steel industries.

Ages of Deposits. Brown ores occur in rocks of all ages in Pennsylvania. The oldest of these rocks, 600,000,000 years old or more, are exposed in the southeastern corner of the State. Brown-ore deposits (bog ores) are forming abundantly in the northwestern part of the State at the present time. Brown ores occur at several definite horizons between these two extremes. The distribution of the larger and more important ore-bearing strata are indicated on the following map.

Map showing distribution of brown ores in Pennsylvania.



* Unger, John S. "Effects of Phosphorus on Soft Acid and Basic Open Hearth Steels," Yearbook, American Iron and Steel Institute 1918, p. 172

Attention is invited to the fact that the location of an iron-ore deposit in strata of any definite geological age does not always signify that the ore deposit is of the same age as that of the strata which enclose it. Chemical compounds of iron are soluble in water. Water carrying iron compounds in solution may have the iron precipitated from it. These two statements apply equally well to experiments in a chemical laboratory and to processes of nature.

If iron ores are deposited simultaneously with materials such as clays and sands which afterwards are converted into bedded rocks whose age can be determined, such iron-ore deposits are recognized as being of the same age as the sandstones and shales which result from the consolidation of the sands and clays. On the other hand, a rock stratum may become fractured, and iron-bearing water solutions passing through the fractures may deposit iron ore in them. Such iron-ore deposits are obviously younger than the stratum which contains the ore. Again, iron-bearing solutions passing through a limestone stratum may simultaneously remove lime and deposit the iron. A deposit of this type is called a "replacement." Such deposits also are younger than the strata which the deposits have replaced. For these reasons it is customary to speak of certain iron-ore deposits as being in strata of certain ages without implying that the iron-ore deposits are themselves of that age.

Brown-ore deposits which have been worked as sources of iron ore in Pennsylvania occur in the various rocks of the Proterozoic Era, in the Lower Paleozoic limestones, in rocks of Lower Silurian, Lower Devonian and Middle Devonian age, and in the rocks of the Pennsylvanian and Lower Permian systems (Coal Measures, particularly the Vanport or "ferriferous" limestone.) Of these the most important are the brown ores of the Lower Paleozoic (Cambrian and Ordovician) limestones.

Deposits in Proterozoic rocks. In the early days of the iron industry in Pennsylvania a few deposits in the gneisses and schists of the southeastern part of the State were worked. The deposits were small, irregular, and of only fair grade. The occurrences were usually widely separated, and for these reasons the industry never attained great magnitude in this area.

These deposits were due to leaching of iron from rocks rich in that material by downward-moving waters, and the deposition of the iron in the places from which the ores were mined.

Deposits in Lower Paleozoic rocks. The greatest number and most important brown-ore deposits in Pennsylvania lie in the large valleys underlain by the Lower Paleozoic limestones. These extend through the following counties: Montgomery, Chester, Lancaster, York and Adams; Northampton, Lehigh, Berks, Lebanon, Dauphin, Cumberland, Franklin, and Fulton; and Bedford, Blair, Huntingdon, Mifflin, Center, Clinton and Lycoming.

The great limestone deposits (6,000 feet thick) occupying these valleys were designated No. II by the Second Pennsylvania Geological Survey, with the names Calciferous, Chazy, and Trenton applied to the

three unequal stratigraphic divisions. Since the publication of the reports of the Second Pennsylvania Geological Survey further work in these areas has indicated that other divisions are desirable, and has shown that a classification based on observations in one locality may not be strictly applicable to other localities. As such division and correlation progresses this Survey is in a position to indicate more accurately the relationship of the iron deposits in these areas.

The brown-ore deposits of the great limestone areas are the result of precipitation of iron minerals from waters circulating underground. Opportunities for the circulation or passage of underground waters occurred along fault-planes, in cavernous portions of the limestones, or along the contact-planes of the limestone with the underlying sandstone (or quartzite) and with the overlying shales. Because they are so very much harder and weather-resisting the quartzites are found in more elevated positions on the various folds than are the overlying limestones. Brown ores found along the junction of the limestone and quartzite contain a noticeably greater amount of silica (SiO_2) and less lime (CaO) than those found within the limestones. For these reasons the ores with high silica content were called "mountain ores." The others were designated "valley ores."

The "valley ores" were found at points which were topographically lower than the mountain ores, but higher in the stratigraphic column. A more or less well-defined grouping of deposits occurs at about the middle of the limestone series. This is somewhat discontinuous and its course appears to be erratic because of faults and folds in the strata. Also, fault planes furnished the channels for circulation of waters which caused the formation of deposits apparently unrelated to the established groups.

At about the contact of the limestone series with the overlying shales and slates (Martinsburg shale, No. III, Utica and Hudson River of the Second Pennsylvania Geological Survey) occur other brown-ore deposits. These also are due to the circulation of iron-bearing waters. The Henrietta mines (Blair County) are large developments at this horizon. In this instance, however, faulting may have been very important in the formation of the water-courses.

At the time these deposits were extensively worked (20-40 years ago) all mining was done by hand, and haulage was by horse and cart. It was common to mine and wash 5 or 6 tons of sand and clay to get one ton of ore. The activities necessary to recover 200,000 tons of ore per year from the numerous small mines can hence be easily imagined. A few mines had large annual outputs. In 1900 the Scotia mines (Center County) produced 52,893 tons of ore.*

Deposits in Lower Silurian rocks. Deposits of brown-ores in the Medina (Formation IV, Second Pennsylvania Geological Survey) have been explored and tested. Most of these were merely ferruginous sandstones. Occasionally limonites of poor quality were found. None of

---

* Mineral Resources of the United States, 1900

these deposits were large, nor were they important sources of ore.

Deposits in Lower Devonian rocks. Deposits in rocks of Lower Devonian age are found in the Helderberg or "Lewistown" limestone (No. VI, Second Pennsylvania Survey). As a rule, this horizon is unimportant. Occasionally, however, where conditions for underground circulation were especially favorable, ore bodies of considerable size were formed. The mines northeast of Altoona developed ore bodies of this class.

In Pennsylvania, ores of the Oriskany (No. VII, Second Pennsylvania Geological Survey) have been mined at scattered localities, but these ores, also, are relatively unimportant.

Deposits in Middle Devonian rocks. The Marcellus ores are brown ores in Middle Devonian rocks. This formation was designated No. VIII by the Second Pennsylvania Geological Survey.

Marcellus ores were of importance in the central part of Pennsylvania, particularly in Blair, Huntingdon, Juniata, and Perry counties. Many of these ore deposits, occurring in Marcellus shales, were 15 to 20 feet wide and were worked to depths of 100 feet or more. In the deeper workings iron carbonate was found below the iron oxide, and pyrite below the carbonate. It is obvious that the surface deposits were due to alteration.

Deposits in the Coal Measures. At many places along the outcrops of the Pennsylvanian and Lower Permian* small pockets of brown ores are found, such being due to the oxidation and hydration of siderite (carbonate ore). Frequently, also, the various limestone beds of these series have small amounts of limonite associated with them. These deposits, however, are relatively unimportant compared to the ores of the Vanport limestone. This limestone (called "Ferriferous" limestone by the Second Pennsylvania Geological Survey) contains or has been replaced by considerable masses of limonite in many places on its outcrop in the central western part of the State. It was formerly of great importance, and many of the early small furnaces derived their sole supply from this source.

Analyses. The following analyses indicate the qualities of the brown ores in Pennsylvania:

---

* The Upper Permian is not represented in Pennsylvania.

Analyses of Pennsylvania brown ores.

	1.	2.	3.	4.	5.
Bisulphide of iron	---	---	---	---	---
Sesquioxide of iron	---	---	76.428	60.000	64.821
Sesquioxide of manganese	---	---	1.456	3.517	0.392
Cobalt Sesquioxide	---	---	0.066	---	0.030
Alumina	---	---	1.260	2.321	2.973
Lime	---	---	0.230	0.270	0.650
Magnesia	---	---	0.147	0.398	0.180
Sulphuric acid	---	---	0.008	0.162	0.175
Phosphoric acid	---	---	0.602	0.822	0.116
Carbonic acid	---	---	---	---	---
Water	---	---	12.773	11.138	9.584
Insoluble residue	---	---	7.290	20.590	20.730
	---	---	100.260	99.218	99.651
Iron	47.200	43.900	53.500	42.000	45.375
Manganese	2.709	0.165	1.015	2.449	0.273
Sulphur	0.039	0.038	0.003	0.065	0.070
Phosphorus	0.075	0.164	0.263	0.359	0.051
Insoluble residue	14.980	21.860	---	---	---

	6.	7.	8.	9.	10.
Bisulphide of iron	---	---	---	0.041	0.054
Sesquioxide of iron	67.214	---	---	85.571	49.571
Sesquioxide of manganese	0.985	---	---	0.692	0.845
Cobalt Sesquioxide	0.102	---	---	---	---
Alumina	4.440	---	---	1.775	1.720
Lime	0.290	---	---	0.380	19.950
Magnesia	0.479	---	---	0.432	0.540
Sulphuric acid	0.282	---	---	trace	0.007
Phosphoric acid	0.506	---	---	0.600	0.199
Carbonic acid	---	---	---	none	15.370
Water	9.660	---	---	8.536	6.060
Insoluble residue	16.120	---	---	2.256	5.715
	100.078	---	---	100.283	100.031
Iron	47.050	33.250	44.700	59.919	34.729
Manganese	0.685	---	---	0.482	0.576
Sulphur	0.113	trace	0.031	0.022	0.032
Phosphorus	0.221	0.345	0.197	0.262	0.087
Insoluble residue	---	41.750	18.820	---	---

1. Jessie Kline's mine, northeast of Emaus, Lehigh County, DD p. 27

2. James Kline's mine, Orefield, Lehigh County, DD p. 36

3. Chestnut Hill Iron Ore Co's. bank, Lancaster County, CCC p. 219

4. Large open mine at Henrietta, Blair County T p. 198

5. Scotia bank, screened wash ore, Center County, T4 p. 222

6. Bombshell ore, Dr. Baker's mine, near Altoona, Blair County T p. 132

7. Ore from Oriskany shales, Rock Hill Iron & Coal Co., Orbisonia, Huntingdon County, F p. 120

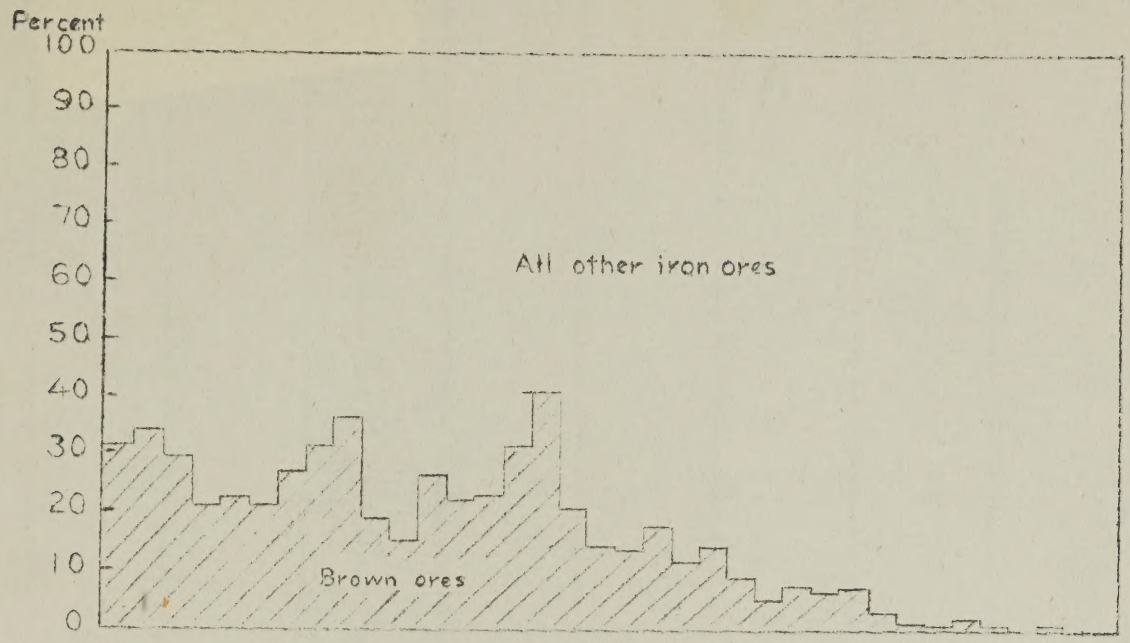
8. Marcellus ore, 5 miles N.E. from Fort Littleton, Fulton County, F p. 128

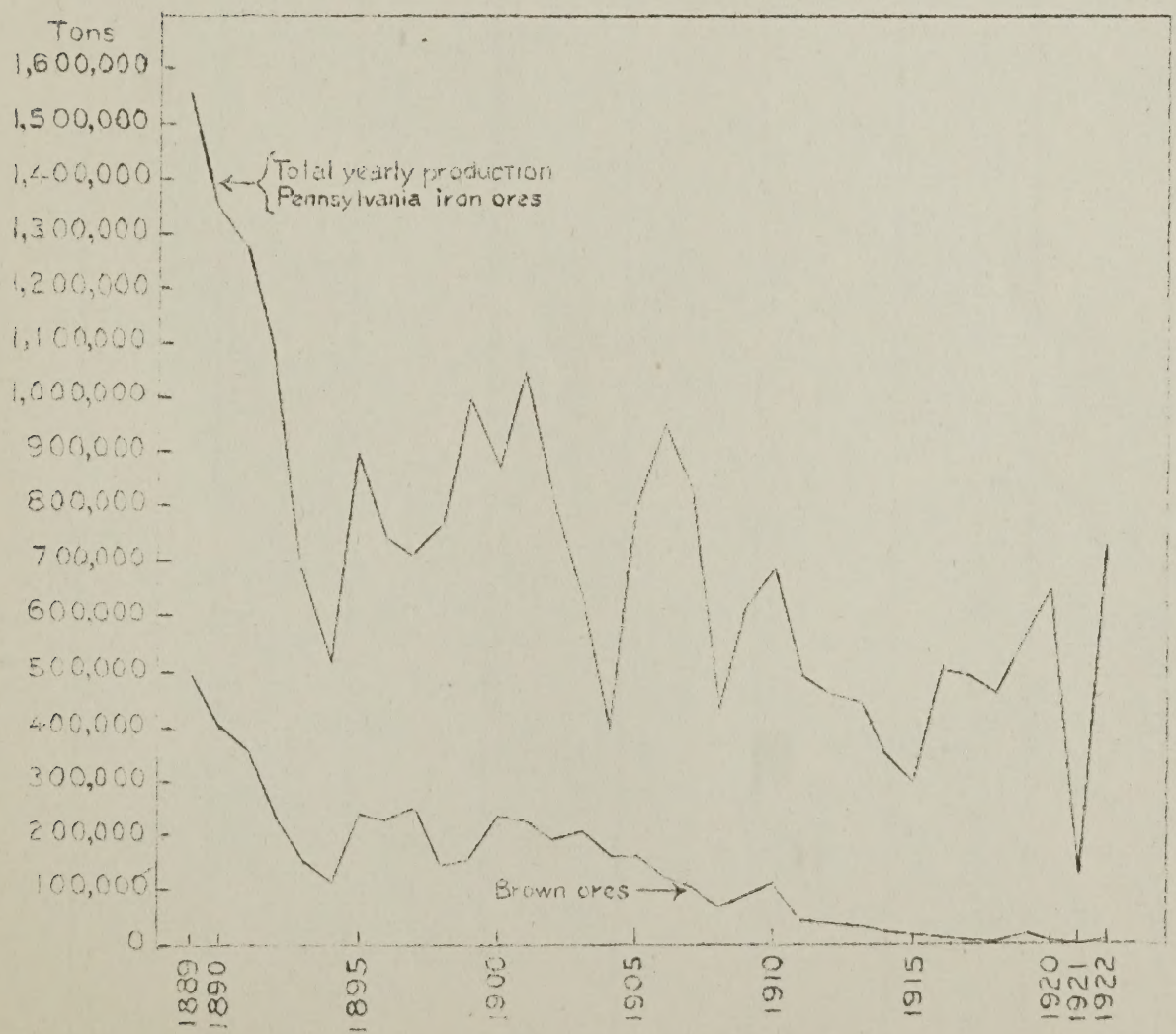
9. "Keel ore" from top of Vanport ("Ferriferous") limestone at Houck & Granniss' mines, Wayne township, Lawrence County, QQ p. 42

10. Vanport ("Ferriferous") limestone ore, Mr. Ziegler's mine, Wayne township, Lawrence County, QQ p. 42

The references above are to reports of the Second Geological Survey of Pennsylvania.

Production: The following diagrams, based on data from U. S. Geological Survey reports, show the relation of the yearly production of brown ore to the total production of all iron ore in Pennsylvania, 1889-1922.


Percent
100
90
80
70
60
50
40
30
20
10
0
All other iron ores
Brown ores


Tons
1,600,000
1,500,000
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Total yearly production
Pennsylvania iron ores
Brown ores
1889
1890
1895
1900
1905
1910
1915
1920
1921
1922